

NEW PHENOLIC COMPOUNDS DERIVED FROM DIALKOXYETHANALS, THEIR PREPARATION PROCESS AND THEIR APPLICATION

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FIELD OF THE INVENTION

The present invention relates to new phenolic compounds derived from dialkoxyethanals, their preparation process and their application.

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SUMMARY OF THE INVENTION

The benefit of the new phenolic compounds derived from dialkoxyethanals is twofold. First of all, new phenolic compounds with a protected aldehyde function can be obtained, which can be used as synthesis intermediates. Then, crosslinkers of phenolic type can be prepared but with the advantage that they do not release formaldehyde during their synthesis or their use. In order to have an idea of the benefit of such crosslinkers, reference may be made to the general article on phenolic resins, advanced in the Kirk-Othmer encyclopaedia, vol. 18, 4th edition, Wiley Interscience, 1996, p 603-644.

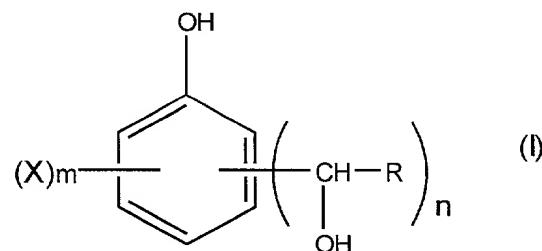
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DESCRIPTION OF THE PREFERRED EMBODIMENTS

A subject of the present invention is thus new phenolic compounds derived from dialkoxyethanals of formula (I)

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in which

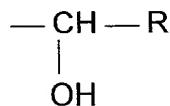
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- R is a dialkoxymethyl group with from 3 to 17 carbon atoms, a 1,3-dioxolan-2-yl group optionally substituted on peaks 4 and/or 5 by one or more alkyl groups comprising from 1 to 8 carbon atoms or a 1,3-dioxan-2-yl group

optionally substituted on peaks 4 and/or 5 and/or 6 by one or more alkyl groups comprising from 1 to 8 carbon atoms.

n has the value 1, 2 or 3 and the group or groups

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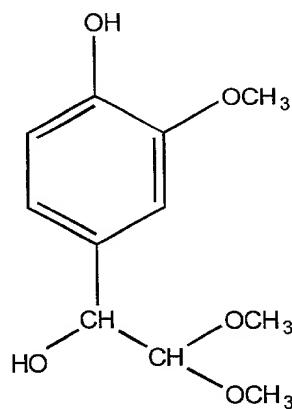


are in ortho and/or in para position of the OH group of the cycle

10 m represents from 0 to 4-n and X represents a functional group such as hydroxyl or halogen such as chlorine, fluorine, bromine, iodine or an alkyl or alkoxy group comprising from 1 to 8 carbon atoms or aryl group comprising from 5 to 12 carbon atoms and optionally 1 or 2 heteroatoms such as nitrogen or oxygen or carboxy or $-\text{CO-Y}$ group in which Y represents an alkyl or alkoxy radical containing from 1 to 8 carbon or amido or amino or thiol radical, on condition that at least one of the ortho or para positions of the phenolic cycle is substituted by a hydrogen, with the exception of the compound 1 described by J. Gardent and J. Likforman, Recent Results

15 Cancer Res. 1966, 22, 23-26.

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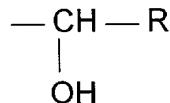
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and their salts with the alkali metals, alkaline-earth metals and amines.

More particularly, a subject of the present invention is new phenolic compounds derived from dialkoxyethanals of formula (I) in which:

- R is a dialkoxyethyl group comprising from 3 to 10, in particular 3 to 7 carbon atoms, preferably a dimethoxymethyl or diethoxyethyl group
- n has the value 2 or preferably 1, the group



being in ortho position or in para position of the OH group of the cycle,

- m represents 0 or 1
- X represents a hydroxyl or halogen group such as chlorine or an alkyl group such as methyl, ethyl or tert-butyl, or alkoxy group such as methoxy or ethoxy, or carboxyl group such as methyl carboxylate or ethyl carboxylate.

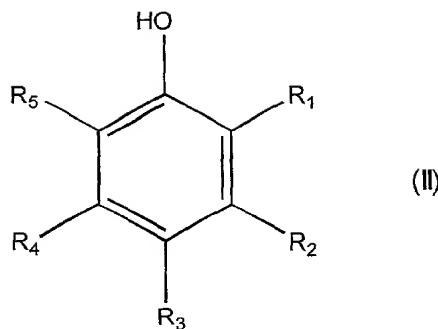
In other preferential conditions, when several groups X are present, they are identical. The alkyl groups comprising from 1 to 8 carbon atoms preferably contain from 1 to 5 carbon atoms, in particular from 1 to 3 carbon atoms.

In an even more particular manner, a subject of the present invention is new phenolic compounds derived from dialkoxyethanals of general formula (I) and more particularly the following compounds:

- 4-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol
- 2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol
- 4-chloro-2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol
- 2-(1-hydroxy-2,2-dimethoxy-ethyl)4-methyl-phenol
- 4-tert-butyl-2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol
- 3-(1-hydroxy-2,2-dimethoxy-ethyl)4-hydroxy-methyl-benzoate.

A subject of the invention is also a preparation process for phenolic compounds derived from dialkoxyethanals of formula (I) and their salts with the alkali metals, alkaline-earth metals and amines characterized by the fact that, in the presence of a base:

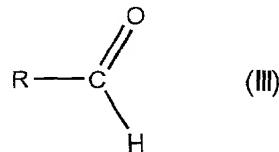
5 - a phenol of formula (II)



10 in which R₁, R₂, R₃, R₄, R₅ can be a hydroxyl radical, a halogen such as chlorine, fluorine, bromine, iodine or an alkyl radical comprising from 1 to 8 carbon atoms or an aryl radical or an alkoxy radical comprising from 1 to 8 carbon atoms or

15 an ester radical comprising from 1 to 8 carbon atoms or an amide radical or an amine radical or a thiol radical, on condition that at least one of the ortho or para positions of the phenolic cycle is substituted by a hydrogen.

- is reacted with an aldehyde of formula (III)



25 in which R is a dialkoxyethyl group, a 1,3-dioxolan-2-yl group optionally substituted on peaks 4 and/or 5 by one or more alkyl groups or a 1,3-dioxan-2-yl group optionally substituted on peaks 4 and/or 5 and/or 6 by one or more alkyl groups in order to obtain the expected compound.

In preferential conditions of implementation of the invention, the phenolic compounds derived from dialkoxyethanals are prepared as follows: 0.1 to 10 moles of aldehyde of formula (III) and 0.1 to 2 base moles are introduced

into a flask per 1 mole of phenol of formula (II). The whole is reacted at a given temperature for a given time. A crude reaction mixture is obtained of which the expected product or products are isolated if desired.

In other preferential conditions of the invention, 0.1 to 5 moles of 5 aldehyde of formula III per 1 mole of phenol of formula II in the presence of 0.1 to 1 mole of base.

Still in other preferential conditions of the invention, the base necessary for the catalysis of the reaction can be a tertiary amine such as tributylamine or triethylamine or an alkali metal hydroxide such as sodium hydroxide or potassium hydroxide, or an alkali metal carbonate such as sodium carbonate or potassium carbonate.

In yet other preferential conditions of the invention, the aldehyde of formula III can be dimethoxyacetaldehyde, diethoxyacetaldehyde, dibutoxyacetaldehyde, 2-formyl-1,3-dioxolane or 5,5-dimethyl 2-formyl 1,3-dioxane.

The phenolic compounds derived from dialkoxyethanals of formula (I) and their salts with the alkali metals, alkaline-earth metals and amines, subject of the invention, can advantageously be used as synthesis intermediates in pharmacy or in plant pharmacy. They can also serve for the preparation of 20 phenolic resins without formaldehyde, the preparation of crosslinkers without formaldehyde of various substrates such as cellulose substrates, non-woven substrates, nylon, polyester, glass.

Finally, a subject of the present invention is the use of the phenolic compounds derived from dialkoxyethanals of general formula (I) and their salts with the alkali metals, alkaline-earth metals and amines, either as synthesis intermediate, or as intermediate for the preparation of phenolic resins without formaldehyde, or as crosslinker without formaldehyde with a substrate which can 25 be a cellulose substrate, a non-woven substrate, of nylon, polyester or glass.

EXAMPLES

The following examples will allow the invention to be better understood.

5 DESCRIPTION OF THE DRAWINGS

Figure 1 represents the variation of the flexural elastic modulus in relation to temperature.

EXAMPLE 1

There are introduced into a 1 L flask:

- 475.3 g (5 moles) of 99% phenol
- 86.7 g (0.5 mole) of dimethoxyethanal in 60% aqueous solution
- 93.4 g (0.5 mole) of tributylamine.

The reaction mixture is heated to 50°C and the course of the reaction is monitored by HPLC. After 24 hours of reaction, the mixture is cooled to ambient temperature.

- 655 g of a crude solution are obtained, containing the phenol in excess, the tributylamine and a mixture of 4-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 2 and 2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 3 with a yield relative to the dimethoxyethanal of 71% for the para compound 2 and 27% for the ortho compound 3, i.e. a total yield of 98%.

A purification of the reaction mixture can be carried out neutralizing the latter with 990 g of a 20% aqueous soda solution (5 moles of soda). 2 phases are then obtained which are separated.

The organic upper phase (90 g) is more than 98% composed of tributylamine. The aqueous lower phase (1547 g) is reacidified by 860 g of a 20% aqueous HCl solution to pH 5-6.

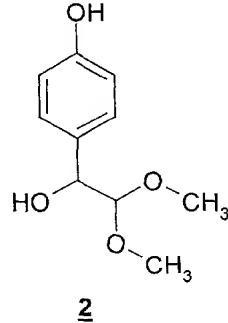
The medium then decants of itself. This acidified aqueous phase is then extracted with 2 times 500 ml of methyl tert-butyl ether (MTBE). The organic

phases obtained are then combined and concentrated under vacuum to give 445 g of a mixture of expected products 2 and 3 and phenol. The phenol is eliminated by distillation under forced vacuum (5mm Hg at 50°C). The residual mixture, containing less than 5% phenol, is then recrystallized from an isopropyl ether/isopropanol mixture.

The precipitate then obtained is filtered, washed with isopropyl ether and dried to give 10.7 g (yield 10.2%) of the expected para compound 2.

A second jet on the mother liquors leads in the same conditions to an extra 15.6 g (yield 15.8%) of the para compound 2.

The ¹H NMR, ¹³C RMN and mass spectrography analyses are in agreement with the expected para compound 2.



Description of the proton spectrum of 2

- 20 3.12 ppm (s; 3H; O-CH₃)
- 3.30 ppm (s; 3H; OCH₃)
- 4.19 ppm (d; J=6.6 Hz; 1H; CH-(OCH₃)₂)
- 4.33 ppm (dd; J=4.3 Hz & J=6.3Hz; 1H; CH-OH)
- 5.15 ppm (d; J=4.7 Hz; 1H; CH-OH)
- 25 6.87 ppm (AB system; JAB=8.6 Hz; 4H; 4H_φ)
- 9.31 ppm (s; 1H; φ-OH)

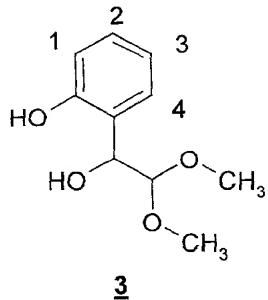
Description of the carbon 13 spectrum of 2

- 53.9 ppm; (1 CH₃; OCH₃)

54.9 ppm; (1 CH₃; OCH₃)
 72.6 ppm; (1 CH; CH-OH)
 107.4 ppm; (1 CH; CH-(OCH₃)₂)
 114.5 ppm; (2 CH; 2CH₂ in ortho of the Cq-OH)
 5 128.5 ppm; (2 CH; 2CH₂ in meta of the Cq-OH)
 132.2 ppm; (1 Cq; Cq₂-CH)
 156.4 ppm; (Cq; Cq₂-OH)

The melting point of this para compound 2 is 90.4°C.

The remaining mother liquors (198 g) consist of a mixture enriched in ortho compound 3. This mixture contains 29.2% of para compound 2 and 14.5% of ortho compound 3. The analysis of this mixture by ¹H NMR is in conformity with the presence of the ortho compound 3.



Description of the proton spectrum of 3

3.17 ppm (s; 3H; OCH₃)
 3.30 ppm (s; 3H; OCH₃)
 25 4.39 ppm (d; J=5.9 Hz; 1H; CH-(OCH₃)₂)
 4.86 ppm (dd; J=5.5 Hz & J=5.5 Hz; 1H; CH-OH)
 5.16 ppm (d; J=5.5 Hz; 1H; CH-OH)
 6.76 ppm (multiplet; 2H; H1 and H3)
 7.02 ppm (m; J=7.0 Hz & J=2.0 Hz; H2)

7.25 ppm (dd; $J=2.0$ Hz & $J=8.2$ Hz, H4)

9.26 ppm (s; 1H; ϕ -OH)

Description of the carbon 13 spectrum of 3

- 5 54.2 ppm; (1 CH3; OCH3)
- 54.3 ppm; (1 CH3; OCH3)
- 67.4 ppm; (1 CH; CH-OH)
- 106.4 ppm; (1 CH; CH-(OCH3)2)
- 115.1 ppm; (1 CH; CH ϕ ; C1)
- 118.7 ppm; (1 Cq; CH ϕ ; C3)
- 127.8 ppm; (1 CH & 1Cq; Cq ϕ -CH and CH ϕ in C2)
- 128.4 ppm; (1 CH; CH ϕ in C4)
- 154.6 ppm; (Cq; Cq ϕ -OH)

EXAMPLE 2

Starting from:

- 1 mole of phenol
- 5 moles of 60% aqueous dimethoxyethanal
- 1 mole of soda 30% diluted in water

20 and heating the reaction medium for 5 hours to 60°C, then cooling it to ambient temperature, a crude solution is obtained containing 58.5% of 4-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 2 and 5% of 2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 3, i.e. in total a yield of 63.5% relative to the phenol introduced.

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EXAMPLE 3

Starting from:

- 5 moles of phenol
- 1 mole of 60% aqueous dimethoxyethanal

- 1 mole of 100% soda in tablet form

and heating the reaction medium for 2 hours in reflux, a crude solution is obtained containing 35% of 4-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 2 and 44% of 2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 3, i.e. in total a yield of 5 79% relative to the dimethoxyethanal introduced.

EXAMPLE 4

Starting from:

- 1 mole of phenol
- 5 moles of 60% aqueous dimethoxyethanal
- 1 mole of 100% soda in tablet form

and heating the reaction medium for 3 hours in reflux, a crude solution is obtained containing 54% of 4-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 2 relative to the phenol introduced.

EXAMPLE 5

There are introduced into a 500 ml flask:

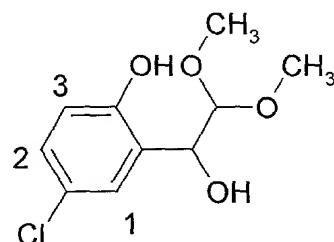
- 262.4 g (2 moles) of parachlorophenol
- 34.7 g (0.2 mole) of dimethoxyethanal in 60% aqueous solution
- 37.4 g (0.2 mole) of tributylamine.

The reaction mixture is raised to 60°C and left to react for 14 hours at 20 60°C. The mixture is cooled to ambient temperature and 404 g of 20% aqueous soda is added and then 100 ml of water.

The aqueous phase is extracted with 200 ml of MTBE, then a second time, with 100 ml of MTBE. The aqueous phase is then neutralized at pH 5 by a 25 20% HCl solution then it is extracted with 200 ml then 100 ml of MTBE. The organic phase obtained is then concentrated under reduced pressure and 318 g of a crude reaction mixture is obtained. The excess chlorophenol is then distilled under reduced pressure from this crude reaction mixture. A new crude reaction mixture is then obtained containing 26% of the 4-chloro-2-(1-hydroxy-

2,2(dimethoxy-ethyl)-phenol 4 relative to the dimethoxy-ethanal used and residual chlorophenol. The compound 4 was able to be purified by recrystallization from toluene (crystallization yield: 61%) and it gives a white solid having the following characteristics:

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**4**

15 - Melting point: 58 °C

Description of the proton spectrum of 4

3.21 ppm (s; 3H; OCH₃)3.30 ppm (s; 3H; OCH₃)20 4.37 ppm (d; J=5.1 Hz; 1H; CH-(OCH₃)₂)

4.86 ppm (dd; J=5.5 Hz & J=5.1 Hz; 1H; CH-OH)

5.30 ppm (d; J=5.1 Hz; 1H; CH-OH)

6.77 ppm (d; J=8.6 Hz; 1H; H3)

7.08 ppm (dd; J=8.6 Hz & J=2.7 Hz; 1H; H2)

25 7.26 ppm (d; J=2.7 Hz; 1H; H1)

9.62 ppm (s; 1H; ϕ -OH)

Description of the carbon 13 spectrum of 4

54.4 ppm; (1 CH₃; OCH₃)

54.5 ppm; (1 CH₃; OCH₃)
 66.7 ppm; (1 CH; CH-OH)
 106.1 ppm; (1 CH; CH-(OCH₃)₂)
 116.6 ppm; (1 CH; CH₃ in 3)
 122.3 ppm; (1 Cq; Cq_φ-Cl)
 127.4 ppm; (1 CH; CH₃; C2)
 128.0 ppm; (1 CH; CH₃; C1)
 130.2 ppm; (1 Cq; Cq_φ-CH)
 153.5 ppm; (Cq; Cq_φ-OH)

EXAMPLE 6

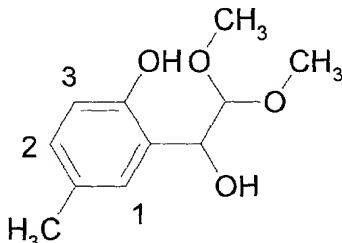
There are introduced into a 250 ml flask:

- 108 g (1 mole) of paracresol
- 34.7 g (0.2 mole) of dimethoxyethanal in 60% aqueous solution
- 37.4 g (0.2 mole) of tributylamine.

The reaction mixture is raised to 60°C and left to react for 25 hours at 60°C. The mixture is cooled to ambient temperature and 198.5 g of 20% aqueous soda is added. The supernatant organic phase containing most of the tributylamine is eliminated. The resultant aqueous phase is then extracted with 2 times 100 ml of MTBE. The aqueous phase is then neutralized at pH 5 with a 20% aqueous HCl solution, then extracted with 100 ml of MTBE.

After concentration under reduced pressure of the organic phase, 117.5 g of a crude reaction mixture is obtained, containing 2-(1-hydroxy-2,2-dimethoxy-ethyl)-4-methyl-phenol 5 with a yield of 36% relative to the dimethoxyethanal introduced and paracresol in excess.

After distillation under reduced pressure of the excess paracresol, the expected compound 5 is obtained with a yield of 29% relative to the dimethoxyethanal introduced.



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Its spectral characteristics are as follows:

Description of the proton spectrum of 5

2.19 ppm (s; 3H; ϕ -CH₃)
 3.18 ppm (s; 3H; OCH₃)
 3.32 ppm (s; 3H; OCH₃)
 4.39 ppm (d; J=5.5 Hz; 1H; CH-(OCH₃)₂)
 4.33 ppm (d; J=5.9 Hz; 1H; CH-OH)
 5.12 ppm (s broad; 1H; CH-OH)
 6.66 ppm (d; J=8.2 Hz; 1H; H3)
 6.85 ppm (dd; J=7.8 Hz & J= 1.6 Hz; 1H; H2)
 7.06 ppm (d; J=1.6 Hz; 1H; H1)
 9.03 ppm (s; 1H; ϕ -OH)

Description of the carbon 13 spectrum of 5

20.3 ppm; (1 CH₃; ϕ CH₃)
 54.1 ppm; (2 CH₃; OCH₃)
 67.5 ppm; (1 CH; CH-OH)
 106.3 ppm; (1 CH; CH-(OCH₃)₂)
 114.9 ppm; (1 CH; CH ϕ in C3)
 126.8 ppm; (1 Cq; Cq ϕ)
 127.4 ppm; (1 Cq; Cq ϕ)
 128.1 ppm; (1 CH; CH ϕ ; C2)
 128.7 ppm; (1 CH; CH ϕ ; C1)

152.3 ppm; (Cq; Cq ϕ -OH)

EXAMPLE 7

- There are introduced into a flask:

5 - 150 g (1 mole) of paratert-butylphenol

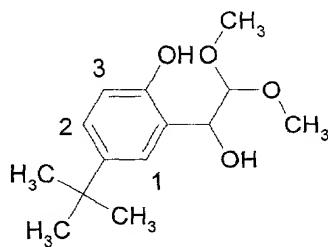
- 34.7 g (0.2 mole) of dimethoxyethanal in 60% aqueous solution
- 37.4 g (0.2 mole) of tributylamine.

10 The reaction mixture is raised to 60°C and left to react for 28 hours at 60°C.

15 A crude reaction mixture is obtained containing 41%, relative to the dimethoxyethanal introduced, of 4-tert-butyl-2-(1-hydroxy-2,2-dimethoxy-ethyl)-phenol 6. This crude reaction mixture is cooled to ambient temperature and 1600 g of water is added then 170 g of 20% aqueous soda. The aqueous phase is extracted 3 times with 200 ml of MTBE, then it is neutralized at pH 5 by a 20% aqueous HCl solution.

20 The aqueous phase is then extracted with 500 ml of MTBE, the organic phase resulting from this being concentrated under reduced pressure. 91.7 g of a crude reaction mixture is then obtained, containing paratert-butylphenol in excess and the expected product 6.

25 After distillation under reduced pressure of the excess paratert-butylphenol, the expected product 6 is obtained with a yield of 34% relative to the dimethoxyethanal introduced. After recrystallization from cyclohexane, the expected product 6 is obtained with a yield of 28% relative to the dimethoxyethanal introduced.



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6

Its characteristics are as follows:

- Melting point: 86°C

Description of the proton spectrum of 6

10 1.23 ppm (s; 9H; ϕ -(CH₃)₃)
 3.17 ppm (s; 3H; OCH₃)
 3.30 ppm (s; 3H; OCH₃)
 4.39 ppm (d; J=5.9 Hz; 1H; CH-(OCH₃)₂)
 4.83 ppm (dd; J=5.5 Hz & J=5.5 Hz; 1H; CH-OH)
 15 5.15 ppm (d; 1H; J=5.1 Hz; CH-OH)
 6.66 ppm (d; J=8.6 Hz; 1H; H3)
 7.07 ppm (dd; J=7.8 Hz & J=2.7 Hz; 1H; H2)
 7.28 ppm (d; J=2.2 Hz; 1H; H1)
 9.04 ppm (s; 1H; ϕ -OH)

20

Description of the carbon 13 spectrum of 6

31.4 ppm; (3 CH₃; ϕ -(CH₃)₃)
 33.7 ppm; (1 Cq; Cq Tbu)
 54.2 ppm; (2 CH₃; OCH₃)
 25 67.8 ppm; (1 CH; CH-OH)
 106.3 ppm; (1 CH; CH-(OCH₃)₂)
 114.5 ppm; (1 CH; CH ϕ ; C3)
 124.3 ppm; (1 CH; CH ϕ ; C2)
 125.0 ppm; (1 CH; CH ϕ ; C1)

126.7 ppm; (1 Cq; **Cq ϕ -CH**)

140.5 ppm; (1 Cq; **Cq ϕ**)

152.2 ppm; (Cq; **Cq ϕ -OH**)

5 **EXAMPLE 8**

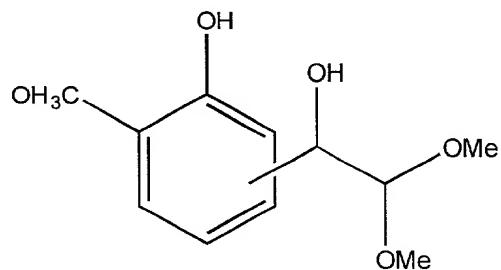
There are introduced into a flask:

- 17.3 g (0.1 mole) of dimethoxyethanal in 60% aqueous solution
- 125.4 g (1 mole) of guaiacol
- 18.7 g (0.1 mole) of tributylamine

The mixture is heated to 60°C and left to react with constant stirring at this temperature for 24 hours.

After cooling, 161 g of a crude reaction mixture is obtained, containing in particular the excess guaiacol, the tributylamine and the condensation products present in the form of 2 isomers, probably ortho and para, of the hydroxyl group of the phenol in the proportions 72/28.

65 g of this crude mixture is concentrated under reduced pressure in order to eliminate most of the water then the excess guaiacol and the tributylamine, to give 7.6 g of a brown oily residue enriched in expected compounds which can then be analysed by CPG/mass spectrometry coupling which gives the following spectra:



1st (majority) isomer 7a:

MS/IE: 228 (M+)

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Principal fragments: 210, 196, 167, 165, 153, 151, 137, 133, 125, 109, 93, 81, 75, 65, 53, 47

2nd (minority) isomer 7b:

MS/IE: 228 (M+)

Principal fragments: 210, 196, 167, 165, 153, 151, 137, 133, 125, 109, 93, 81, 75, 65, 53, 47

EXAMPLE 9

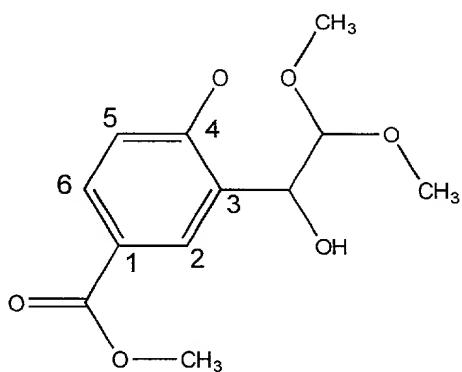
There are introduced into a flask:

- 35.1 g (0.2 mole) of dimethoxyethanal in 60% aqueous solution
- 153.7 g (1 mole) of methyl parahydroxybenzoate
- 37.4 g (0.2 mole) of tributylamine

The mixture is left to react with constant stirring at 60°C for 23 hours
20 then a further 27 hours at 70-75°C.

The mixture is cooled to ambient temperature, the excess methyl parahydroxybenzoate precipitates.

After filtration, 92 g of a brown-coloured filtrate is obtained, enriched in 3-(1-hydroxy-2,2-dimethoxy-ethyl)-4-hydroxy-methylbenzoate 8, the spectral characteristics of which are as follows:



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Description of the proton spectrum

3.19 ppm (s; 3H; O-CH₃)
 3.30 ppm (s; 3H; O-CH₃)
 3.78 ppm (s; 3H; COOCH₃)
 4.37 ppm (d; J=5.1 Hz; 1H; CH-(OCH₃)₂)
 4.9 ppm (d; J=5.5 Hz; 1H; CH-OH)
 6.84 ppm (d; J=8.6 Hz; 1H; H5)
 7.69 ppm (dd; J=8.4 Hz & J=2.2 Hz; 1H; H6)
 7.94 ppm (d; J=2Hz; 1H; H2)

15

Description of the carbon 13 spectrum

51.6 ppm; (1 CH₃; COOCH₃)
 54.4 ppm; (1 CH₃; OCH₃)
 54.5 ppm; (1 CH₃; OCH₃)
 66.7 ppm; (1 CH; CH-OH)
 106.4 ppm; (1CH; CH-(OCH₃)₂)
 115.0 ppm; (1CH; CH ϕ ; C5)
 120.3 ppm; (1 Cq; Cq ϕ -COOMe; C1)
 128.3 ppm; (1 Cq; Cq ϕ -Ch; C3)
 129.6 ppm; (1 CH; CH ϕ ; C2 or C6)
 130.3 ppm; (1CH; CH ϕ ; C6 or C2)
 159.2 ppm; (1 Cq; Cq ϕ -OH; C4)
 166.1 ppm; (1 Cq; COOMe)

EXAMPLE 10

The aim of the examples is to show the thermocrosslinking properties of the phenolic compounds derived from dialkoxyethanals of formula (I) and their salts with the alkali metals, alkaline-earth metals and amines.

5

a) Preparation of the samples**Sample 1**

5 g of the crystallized compound described in example 1 is solubilized in 5 g of distilled water. Whatman no. 1 paper is then impregnated with the obtained solution (pH about 5).

Once impregnated, the paper is allowed to drip, dried for 12 hours at ambient temperature then at 40°C for an hour.

Sample 2

4.4 g of the crystallized compound described in example 1 and 0.3 g of hexahydrated magnesium chloride are solubilized in 4.4 g of distilled water.

Whatman no. 1 paper is then impregnated with the obtained solution. Once impregnated, the paper is allowed to drip, dried for 12 hours at ambient temperature then at 40°C for an hour.

20

Sample 3

Whatman no. 1 paper is impregnated with the crude solution obtained in example 4.

Once impregnated, the paper is allowed to drip, dried for 12 hours at ambient temperature then at 40°C for an hour.

Sample 4

4.2 g of magnesium chloride hexahydrate is solubilized in 100 g of crude solution of Example 4.

Whatman no. 1 paper is then impregnated with the obtained solution. Once impregnated, the paper is allowed to drip, dried for 12 hours at ambient temperature then at 40°C for an hour.

5 **b) ATMD measurement of the prepared samples**

The different paper samples are then tested in ATMD in the following conditions:

- apparatus: ATMD MKIII (Rheometrics) – sensor: mixed up to 500°C
- Mode: “Double beam mode” (Dual Bending Cantilever)
- Frequency: 1 Hz
- Heating rate, temperature: 4.0°C/mn, from 30°C to 240°C
- Dimensions of the sample: 2 x 10 x 0.2 mm

The crosslinking is made visible by the variation of the E' modulus (elastic modulus) in relation to the temperature: cf. attached graphs.

In all cases, it is noted that a crosslinking takes place through an increase and a change in pitch of $\log(E')$ at temperatures above 110°C.

For samples 1 and 2, respectively without or with catalyst, crosslinking starts around 135°C-140°C; for samples 3 and 4, respectively without or with catalyst, the start of crosslinking operates around 165°C and 175°C.

It will be noted that the Whatman no. 1 paper alone experiences no variation in modulus of the same type in the same conditions.